Diseases of Small Grain

and their control

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Upper left: Scald on barley.
Lower left: Nematode galls, sound wheat, stinking smut balls, cockle seed.

Upper right: Stripe on barley.
Lower right: Scab and sooty mold on wheat; note the pinkish color of the scab fungus in contrast to the sooty mold.

CONTENTS

SUMMARY OF DISEASE CONTROL RECOMMENDATIONS

Cereal plants cannot be cured of diseases once they become infected. It is inexpensive and practical to control cereal diseases by using the following simple rules:

1. Grow recommended varieties.
2. Plant clean, disease-free, chemically treated seed.
3. Follow rotations which locate cereal crops as far from the same crop of the previous season as possible.
4. Do not use manure containing cereal straw on cereal crops.
5. Plant at the recommended depth—never more than 1" deep.
6. Eradicate volunteer cereal plants.
7. Consult your Extension Service freely about your plant disease problems.

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Diseases of Small Grains and Their Control

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Diseases of small grains cause a heavy annual loss to Virginia farmers. Often such losses are attributed to soil or climatic conditions, because plant-disease organisms are so small that they are easily overlooked. Proper attention to disease control measures will usually aid in increasing crop yields and net profits.

Certain of these diseases, such as the seedling blights and smuts, are seed borne and the spread of the disease-producing organisms to clean fields can be prevented or reduced by seed treatment. Seed treatment with proper chemicals also helps protect the young seedlings from soil borne disease-producing organisms during periods when the soil is cold and wet and therefore unfavorable for plant growth. Resistant varieties are available for the control of certain diseases. Growing recommended varieties in a rotation will help materially in controlling many small grain diseases.

This bulletin is published in response to many requests from farmers and county agents for more detailed information on small grain diseases and their control. Herein are discussed some of the most important diseases of these crops, including (1) their description, (2) control, (3) the importance of seed treatment, (4) instructions for treating seed, and (5) the importance of planting certified seed.

Wheat

Stinking Smut or Bunt

Stinking smut may occur wherever wheat is grown. The disease causes smut balls to form in place of wheat kernels. The smut balls are light in weight, shaped somewhat like wheat kernels but usually shorter and plumper, and varying in color from silvery gray to dark brown. (Plate 1) Generally all of the kernels in a head are affected and all the heads in a plant are diseased. Such heads are usually darker green when young and almost always shorter and somewhat darker in color when matured. Diseased heads have a fishy odor, hence, the common name "stinking smut." The loss from stinking smut results not only from the damage to the grain itself but also from the fetid odor of the smut. A small quantity of smut mixed with grain is sufficient to reduce materially the grade and consequently the market value.

Control: Since this smut is carried from one crop to the next as smut balls, or as spores on the surface of the seed, a control measure to be effective must remove the smut balls and kill the spores. This may be accomplished by first cleaning the seed thoroughly with a fanning mill and then treating the seed with one of the recommended fungicides. See page 22 for directions on seed treatment.

Loose smut is present to some extent in nearly every wheat field in the state. This disease is first observed at the time of heading. It is quite different from stinking smut in that all of the glumes or chaff, as well as the kernels of an affected head, are transformed by the smut fungus into a loose, dusty, black mass of spores (Fig. 1). This mass of spores soon disappears, leaving only the barren spikes with a few of the dusty, dark spores attached, as evidence of the smutted heads so conspicuous a few days previously. These spores are blown by the wind to open flowers of surrounding heads where the new infection occurs. If these infected kernels are planted, they will cause smutted heads the following year.

Control: Any seed treatment to be effective must destroy the fungus which lives within the infected kernels. It is this fact which makes surface applications of fungicides ineffective. Loose smut may be controlled by hot-water treatment, using resistant varieties, or certified seed. The hot-water treatment is difficult and laborious and is not recommended for use by the aver-

Figure 1.—Healthy head of wheat, left, and three stages of loose smut, right.

age farmer. Specialized seed growers should hot-water treat a few bushels of seed to be used in planting plots to obtain smut-free seed for the following year's planting. Such a seed plot should be planted several hundred yards from other wheat fields to avoid reinfection. "See page 24 for directions for making the hot-water treatment." Leap, Vahart, and Thorne varieties are partially resistant to loose smut.

The farmer should plant certified seed, which will be comparatively free of loose smut.

Black Stem Rust

Black stem rust (Fig. 2) is one of the most destructive diseases of small grains. Badly rusted fields yield light-weight and poor-quality grain. Early in the spring the rust spores that have lived through the winter on straw and stubble germinate and cause rust on the leaves of nearby common native barberry bushes, where the first stage of the life cycle of the rust is spent. About the middle of May, in Virginia, the rust spores are carried by wind from the barberry bushes to small grains and grasses, on which they cause the red or summer stage of the disease. How quickly the rust spreads from one grain field to another depends upon the weather. During hot, muggy weather a new crop of rust spores may be produced every 10 days. As the grain ripens, black spores are produced on the stems, leaves, leaf sheaths, and heads, the stem being most severely affected. These black spores, which give the disease its name, remain alive throughout the winter and the life cycle is completed the following spring on barberry. If no barberry bushes are near, the disease cycle may not be completed.

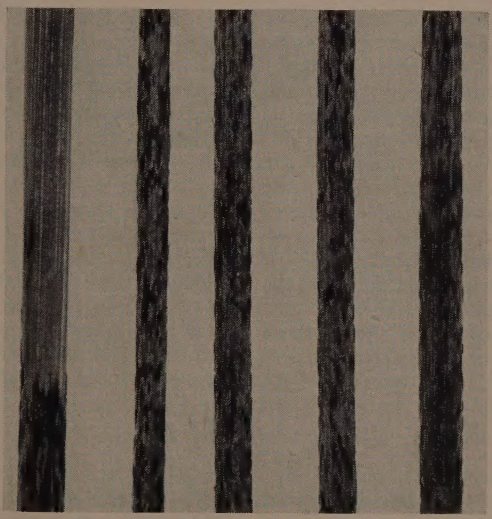

Figure 2.—Black stem rust of wheat.

Control: Seed treatment is of no value in controlling black stem rust because the fungus that causes this disease is not carried in or on the seed. The only practical control available at the present time is the use of resistant varieties and the destruction of the common or native barberry. Without barberry, the host plant, the fungus cannot complete its life cycle. Complete control of black stem rust is difficult to obtain because wind-blown spores may infect wheat from barberry bushes growing at a considerable distance. The Japanese barberry frequently used as an ornamental around homes is not susceptible to the rust and therefore is harmless.

Considerable progress has been made in developing varieties of wheat resistant to black stem rust; however, no resistant varieties suitable to Virginia conditions are yet available.

Orange Leaf Rust

Orange leaf rust is a very common and occasionally destructive disease of wheat in Virginia. The amount of rust and the subsequent loss depends to a large extent on the amount of rainy or muggy weather; moisture favors infection. Leaf rust develops during the fall and again in the spring and early summer. Since it is often difficult to distinguish between orange leaf rust and black stem rust in the field, the following comparisons may be of help:

BLACK STEM RUST

1. Pustules chiefly on stems.
2. The red stage pustules are narrow, long, parallel to the veins, gradually enlarge, coalesce and rupture. Color—reddish-brown.
3. The black stage is like the red except that it contains a cushion of black spores where red spores were formerly produced.
4. In addition to wheat, black stem rust affects barley, oats, rye, and several grasses. The alternate hosts are the common and native barberry.

ORANGE LEAF RUST

1. Pustules chiefly on leaves.
2. The red stage pustules are small, about the size of a pinhead, round, scattered over the leaf, seldom run together, inconspicuous. Color—reddish-orange.
3. The black stage formed beside the red pustules are inconspicuous, flattened, and do not rupture the leaf.
4. Ordinarily orange leaf rust affects only wheat. The alternate host is meadow rue *(Thalictrum sp.)*.

Control: The use of resistant varieties is the only effective means of controlling orange leaf rust. Atlas 66 is highly resistant to leaf rust, Atlas 50 is moderately resistant, and Nudel is slightly resistant.

Scab or Fusarium Blight

Scab or Fusarium blight is sometimes severe on wheat in Virginia. Symptoms and control are the same for wheat as for barley. See more information concerning this disease under barley scab on page 17.

Nematode Disease

The nematode disease of wheat is caused by an eelworm so small it can be seen only with the aid of a miscroscope. The first symptoms are wrinkled and distorted leaves and enlarged stems of the young infected plants. Later hard dark galls develop instead of seed. These galls are frequently found in the combined or threshed grain. Diseased heads are usually shorter and thicker than the healthy ones, and the glumes are spread farther apart by the nematode galls. At first the galls are of a shiny green color, but later they are brown or black and become hard. Diseased heads remain green longer than healthy ones. Nematode galls are often mistaken for cockle seed and smut balls (Plate 1). Cockle seeds can be distinguished from nematode galls, since the seeds are covered with spines and the nematode galls are smooth. Smut balls are brown but are easily broken up into a dark brown powder and have a fishy odor. Nematode galls are hard. When the contents of the nematode galls are examined under the microscope, the nematodes can be seen moving like eels, hence the popular name "eelworms."

Control: Plant seed that is free from nematode galls, on land that has not grown wheat or rye or had straw from nematode diseased grain spread on the field during the preceding year. This method will eradicate the disease in one year.

Powdery Mildew

Powdery mildew is found on small grains and grasses throughout the state. Every year this disease is destructive to wheat. Since the development of new mildew resistant varieties, powdery mildew has decreased in importance; however, many of the commonly grown varieties of wheat are very susceptible.

Characteristic signs of mildew are grayish-white powdery masses of fungus threads, found either in spots or completely covering the leaf (Plate 2). Later this powdery growth becomes darker gray and may be studded with tiny black dots. Severely infected plants may be stunted and fail to head; the leaves of such plants usually turn yellow and die. After death of the wheat plant, the small black bodies serve as a means of carrying the fungus over seasons. Powdery mildew is more prevalent and causes more damage during periods of cool, cloudy, humid weather.

Control: The most effective and practical means of controlling powdery mildew is by the use of resistant varieties. Atlas 50 is quite resistant and Vahart and Atlas 66 are moderately resistant. Seed treatment is of no value in the control of powdery mildew because the organism causing this disease is not carried on or in the seed.

Glume Blotch

Glume blotch is a disease which occurs on wheat every year to some extent and may be quite injurious during seasons of excessive rainfall.

The disease attacks the heads, leaves, and stems of the wheat plant. The leaves may have brown spots and the stems may be darkened at the nodes. Glume blotch is most conspicuous on the wheat heads, which show definite irregular chocolate-brown spots sprinkled with tiny black dots. Heavily infected heads are badly dwarfed and have shriveled grain. The fungus lives from season to season on wheat chaff and straw and on the surface of seed.

Control: Losses from glume blotch may be reduced by using well cleaned, chemically treated seed in a long crop rotation. See page 22 for details on seed treatment.

Mosaic

Mosaic is caused by a virus which may survive in the soil for several years. Except for being transported in infested soil, it is not known how the virus is spread from one area to another. The symptoms of mosaic first appear in late winter. Affected plants in scattered areas of a field are stunted, the leaves are narrower than those of unaffected wheat and have characteristic yellow streaks and mottling. Leaf tips of the very susceptible Atlas varieties may be reddened or bronzed. As the plants tiller and advance toward the boot stage, stunting and mottling become more apparent. After heading, the diseased plants are more irregular in height than disease-free plants. The severity of these symptoms is varied by the intensity of the virus infestation, climatic conditions, and variety of wheat. Atlas 50 and Atlas 66 show more striking symptoms than other recommended varieties, but Leap, Thorne, Vahart, and V.P.I. 131 may be mildly affected. In heavily diseased fields the yield of wheat may be reduced by 75 percent.

Control: Mosaic is controlled primarily by the use of resistant varieties. Nudel is the most resistant and is the only variety recommended for heavily virus-infested soils. Thorne, Vahart, V.P.I. 131, and Leap's Prolific are recommended for sowing on moderately infested soils. Atlas 50, Atlas 66, and Nittany are highly susceptible and therefore not recommended for planting in fields infested with mosaic. In the absence of mosaic and where they are adapted (Eastern Virginia and Piedmont), the Atlas varieties are higher yielding than other varieties. Thus if an Atlas variety is preferred it may be grown until mosaic appears and reduces the value of the crop to that of the resistant varieties. A crop rotation (not including rye) should be followed to prevent a build-up of the virus. The virus is not known to be carried on seed; nevertheless, seed from mosaic-infested areas is not recommended for planting.

Take-all

Take-all of wheat has become quite prevalent during the past few years and has caused considerable concern. This disease is spectacular because of the rapid killing of affected plants. Take-all is caused by

a soil-borne fungus which attacks the roots and basal stems of wheat, rye, barley, and certain grasses. The fungus is present in many soils and is especially favored by cold, wet weather in the spring. The disease can be recognized by the lead-colored to black discoloration at the base of the stem, which may extend 2 inches above the soil line. On severely affected plants the feeding roots turn brown and rot off, so that the plants may be easily pulled from the soil. Diseased plants are much shorter and the heads bleach and ripen or die prematurely. Affected heads may produce a few shriveled kernels. After the infected plants die, the whitish heads may be seen from a considerable distance. Later these plants become much darker. All varieties of wheat are susceptible to the take-all fungus. When wheat follows wheat in an infested field, there is a rapid increase of the fungus in the soil and severe injury frequently results.

Control: Take-all is effectively controlled by crop rotation. (It is especially important that wheat not follow wheat or barley continuously.)

Miscellaneous Diseases of Wheat

Root Rots and Seedling Blight: In addition to the ones discussed previously, there are several soil-borne organisms that may attack the roots, crowns, and stems and cause root rots and seedling blights. Diseased roots are usually stubby and produce many lateral branches that appear moldy; or, sometimes the roots develop a light brown soft rot. Some of the root-rot and seedling blight organisms cause brownish streaks extending up the stem 6 to 8 inches. This type of infection weakens the straw and causes much lodging of the plants.

Anthracnose is a common disease of minor importance on wheat. It may occur on all parts of the plant, causing small black elevated spots about the size of a pinpoint. See discussion under "rye," on page 18.

Other wheat disease sometimes found are *downy mildew, ergot,* and *black chaff.*

Control: Planting good, clean, chemically treated seed in a rotation is the best method of controlling these diseases. See page 22 for directions for treating seed.

Oats

Loose and Covered Smuts

Prior to the practice of seed treatment the loose and covered smuts of oats were found wherever this crop was grown. If oats are infected with loose smut, the grain and much of the chaff are replaced by a powdery brown or black spore mass which shatters as the head matures, leaving only a bare stalk at harvest time. Covered smut differs from loose smut in that it causes less destruction of the flowers, and produces less dusty spore masses which are much blacker than those of loose smut and, by remaining enclosed within the flower parts, the spores are not shaken out or blown about by the wind so

Figure 3.—Loose smut of oats, left; healthy head, center; covered smut, right.

readily (Fig. 3). In both smuts, all of the heads of an affected plant are generally smutted. Diseased plants are often shorter and stand more erect than normal plants. Although the two smut diseases differ slightly in their symptoms and are caused by two distinct fungi, they may be controlled by the same chemical treatment.

Control: Seed treatment with a recommended fungicide is the most satisfactory method of controlling these smuts. Allow the treated seed to remain in sacks for at least 24 hours before planting. See full directions for seed treatment on page 22.

Crown Rust

Crown rust is distinct from the stem rust of oats and can be distinguished in both the yellow and black rust stages. Crown rust appears, primarily on the leaves, (Plate 2), but the leaf sheaths may also be covered with small, somewhat elongated pustules of an orange-yellow color. This is the most conspicuous stage and appears early in the season. Later, inconspicuous pustules are formed which contain the black or winter spores. They do not break through the leaf surface, but appear as long raised black specks just beneath it. The leaves on heavily infected plants are killed and the stems are so weakened that severe lodging may result.

Grain is light and chaffy in proportion to the earliness and severity

of the disease. The alternate host of crown rust is buckthorn.

Control: Since winter oats mature early they largely escape crown rust. Resistant varieties offer the most practical means for controlling crown rust on spring oats. The only spring oat variety recommended in Virginia which is resistant to crown rust is Mo. 0-205.

Black Stem Rust

Black stem rust on winter oats generally is not as common nor as injurious as it is on wheat, but it may be very severe on susceptible spring oats. For a full discussion of symptoms, see description under "wheat," page 7. The fungus causing black stem rust on oats is a different variety from that causing black stem rust on wheat; consequently, it is possible for a field of oats to be severely rusted while an adjacent field of wheat may be almost free from the disease, or vice-versa.

Control: Andrew and Mo. 0-205, currently recommended spring oat varieties, are moderately resistant to black stem rust. General control measures for black stem rust of oats are the same as for that of wheat. See page 8.

Victoria Blight

Victoria blight (Plate 2) is very destructive to oats in some areas. Since high temperatures favor Victoria blight, susceptible late-maturing spring oats may be severely damaged, while winter oat varieties usually escape.

Victoria blight is seed borne and soil borne. Infested seed may rot in the soil before they germinate, but usually the plants are attacked in the seedling stage as they emerge from the soil. Later the disease spreads to mature plants. The first symptom of the disease is the appearance of reddish-brown stripes along the edges of the lower leaves. Wilting and a gradual fading of the normal green color usually follows. Diseased seedlings show various stages of rot at the roots, crown, and first node. Severely infected seedlings die. Less severely affected seedlings may live to maturity but as weakened plants. In later stages, the fungus attacks the plants in the region of the lower stem, causing a browning of the tissue, which later becomes overgrown by the dark brown fungus. Infected plants may ripen prematurely and lodge excessively. Yields are greatly reduced.

Control: Victoria blight of spring oats may be controlled by the use of resistant varieties such as Andrew, Clinton, and Mo. 0-205. The early maturing winter oat varieties, Arlington, Atlantic, Fulgrain, and Victorgrain 48-93, are susceptible but escape the disease unless they are planted early. These varieties should not be planted for early fall grazing. Lee and Forkedeer are resistant and should be planted if early fall grazing is desired. As a further precaution, all seed should be treated with a recommended fungicide, several days before planting, as outlined on page 22.

Red Leaf Disease

Red leaf of oats is quite new in Virginia; however, this disease has been observed for several years in other areas. The disease causes the lower leaves to turn red or reddish-brown. Soon the upper leaves also show the same symptoms. The disease usually occurs in patches of from one to several feet in diameter, but sometimes scattered diseased plants are found. At maturity the plants in these diseased patches are shorter than the surrounding healthy plants and are visible at a distance because of their red color. All varieties appear to be susceptible in varying degrees.

It has been reported that red leaf may be caused by a virus that is carried by aphids that feed on young oat seedlings. Studies are now in progress at several experiment stations to determine whether some varieties are less affected than others and to develop varieties resistant to red leaf. No control recommendations are available at this time other than to plant adapted varieties and follow recommendations in regard to seed treatment, fertilization, etc.

Miscellaneous Diseases of Oats

Leaf spot or blotch is one of the most common diseases of oats and under some conditions may cause serious losses. Small reddish-brown spots appear on the leaves. These spots usually grow together to form long irregular brown blotches. Severely infected leaves turn yellow and die. The fungus causing leaf blotch is carried on the seed and it may also live over in the soil and on diseased plant refuse. All commonly grown oat varieties are susceptible to this disease.

Foot rots, scab, powdery mildew, bacterial blights, anthracnose, halo blight, Septoria leaf blotch, and *downy mildew* are occasionally found on oats in Virginia but are not considered at present to be of economic importance.

Control: The use of well cleaned, high quality seed of adapted varieties that have been treated with a recommended fungicide and planted in a crop rotation is the best safeguard against these diseases.

Barley

Covered Smut

Covered smut may be found in almost every barley field planted with untreated seed. The first evidence of covered smut is observed about two weeks after the barley blooms. Smutted heads usually appear later than healthy ones. Purplish-black spore masses replace the grain and glumes, and are covered by a thin membrane, which remains intact until the grain is harvested. Upon combining, threshing, etc., the membranes of the spore masses break and the spores are dispersed (Fig. 4). The disease organism is carried from one year to the next on the surface of barley seed which have become contaminated during combining and threshing. When contaminated grain is planted

Figure 4.—Loose smut of barley, left; covered smut, center; healthy head, right.

the smut spores germinate simultaneously with the barley seed and infect the young seedlings before they appear above the ground. After infection, the fungus develops inside the plant and replaces the flowering parts at heading time.

Control: Covered smut can be effectively controlled by treating the seed with a fungicide as recommended on page 22.

Brown Loose Smut

Brown loose smut is the most destructive disease of barley in the state. Occasionally, from 10 to 20 percent of the heads in a field may be affected. The symptoms of brown loose smut of barley are the same for loose smut of wheat. See page 6 for a full description of "wheat loose smut." Instead of grains, heads of infected plants develop masses of powdery, olive-brown spores held by a thin, silvery membrane which usually ruptures about the time of blossoming of

healthy plants (Fig. 4). Smutted plants usually head earlier than unsmutted plants. The infected heads stand high on the stalks and thus offer an excellent opportunity for the healthy plants where the fungus gains such a foothold in the seed that, unless hot-water treated, the seed will carry the disease over to the next crop.

Loose and covered smuts of barley are frequently confused. The following will help to tell them apart.

COVERED SMUT

1. Smut masses usually persist on the stalk until harvest.

2. The smut mass is purplish-black in color, enclosed in a gray membrane that persists until harvest.

LOOSE SMUT

1. Smut masses are liberated soon after emerging, leaving barren stalks before harvest.

2. The smut mass is olive-brown in color, enclosed in a thin, silvery membrane which ruptures early.

Control: Since the brown loose smut fungus is within the seed rather than on the surface, chemical seed treatments have no effect on it. At present, the only effective measure for controlling brown loose smut is the hot-water treatment, which is a rather difficult procedure and has not proven very popular with the average farmer. See page 24 for details on hot-water seed treatment.

The most practical means of reducing the prevalence of loose smut is to plant certified seed, because certified seed has been grown in fields comparatively free of loose smut.

Black (false) Loose Smut

Black or false loose smut of barley is very difficult to distinguish from brown loose smut in the field. Heads of black loose smut generally appear later than those of brown loose smut. The mass of dark brown to black spores is enclosed in a fragile membrane, giving the heads a partially covered appearance. Black loose smut spores are washed down by rain and blown by wind less readily than brown loose smut spores.

Control: Because the spores are borne externally on the surface of the seed, black loose smut can be controlled by fungicidal treatments. See page 22 for details on seed treatment.

Stripe

The barley stripe disease ranks in importance with the smuts as a very serious disease. The first evidence of this disease usualy appears a few weeks before the plants head (Plate 1). At this time, one or more long, yellowish stripes appear on the older leaves. These yellow streaks soon become covered with a brown mold. The affected tissue dies and the leaf blades split. Affected plants are usually

shorter and their heads often fail to emerge, or if they do emerge, they are blighted, brown, and much smaller. Blighted heads stand erect and are conspicuous at ripening time, in contrast to normal heads.

Control: Seed treatments with a recommended fungicide will control stripe. Sanitation and crop rotation are important supplemental control measures. See page 22 for full directions on seed treatment.

Scald

In recent years scald has caused considerable leaf spot and defoliation of barley, with a subsequent reduction in yield. Scald developes rapidly during cool spring weather. First spots appear on the leaf blades and sheaths as irregular dull green water-soaked blotches which later change from dull green to brown, and finally to a bleached straw color with conspicuous brown margins (Plate 1). The fungus that causes scald lives through summer and winter on infected residue from the previous crop and is also seed borne. New infections appear in winter and early spring.

Control: Among the recommended varieties of barley in Virginia, Hudson is the most resistant to scald; therefore, where this disease has been severe in the past, Hudson should be grown. Kentucky and Ky.-1 are moderately resistant. Always follow a rotation. As a supplemental control practice the seed should be treated as described on page 22.

Powdery Mildew

Powdery mildew appears on barley almost every year in Virginia. The symptoms and life history of this disease are the same as those for powdery mildew of wheat, discussed on page 9. See (Plate 2).

Control: The use of resistant varieties is the only practical means of controlling powdery mildew. Wong, Hudson, and Kenbar are resistant.

Scab or Fusarium Blight

Scab occurs wherever small grains are grown. If wet, muggy weather prevails during the flowering period of the grain, this disease may become very destructive. The fungus causing scab attacks wheat, barley, rye, oats, corn, and a number of grasses. Scab may cause a blight of the young seedling or a blast of the maturing head. Badly infected seed may not even germinate, and if it does germinate the diseased seedlings may be killed soon after they appear above ground. Infected seedlings are first stunted; later they turn yellow, the roots rot, and a pink-colored mass of the fungus may cover the roots. The most characteristic and conspicuous symptom of scab on barley heads appears soon after flowering. A part or all of the spikelets in the head may be affected. They appear to be prematurely ripened, lose their green color, turn pale

yellow and die. Light pink or salmon-colored spore masses may be formed along the edge of the glumes of affected spikelets (Plate 1). Spikes infected after seed formation usually produce shriveled grain. Scabby barley is poisonous to livestock (see page 26.)

Control: Scab is difficult to control, but the losses caused by it may be greatly reduced. The use of well-prepared, clean land, (free of infected straw and corn stalks), and high-grade, cleaned and chemically treated seed of recommended varieties will reduce considerably the losses from this disease. Old corn stalks, straw of grains and grasses in the field and adjoining areas should be removed or carefully plowed under. This is essential because the scab fungus lives over winter on such material and attacks the grain crop that follows. If it is necessary to use barley containing scabbed kernels for seed, the grain should be cleaned thoroughly with a fanning mill to remove all scabbed and shriveled grain, then treated with a recommended fungicide. See page 22 for instructions on seed treatment.

Miscellaneous Diseases of Barley

Spot Blotch and Net Blotch of barley are quite similar in appearance and affect the plant in the seedling stage. These diseases may cause severe blighting and death of the seedlings in the fall and early spring. The fungi that cause spot blotch and net blotch live over in infected kernels, plant debris, and in the soil.

Black Stem Rust and Leaf Rust: No rust-resistant varieties are yet available. See discussion on page 7.

Other diseases that are occasionally found on barley in Virginia but which are not of economic importance are *anthracnose, ergot, bacterial blight* (Plate 2), and *Septoria leaf blotch.*

Control: Plant clean treated seed in a crop rotation. See page 22 for directions for seed treatment.

Rye

Rye is usually not affected seriously by diseases. However, many of the same or similar diseases that attack other small grains may also be found on rye.

Loose smut, stinking smut, stem rust, leaf rust, scab, Helminthosporium disease, powdery mildew, nematode disease, and *scald* of other small grains are discussed on the preceding pages. The same control measures are equally effective for these diseases on rye.

Anthracnose and *ergot,* however, are more serious on rye than on other small grains. *Stem smut* occurs only on rye.

Anthracnose

Anthracnose is present in most rye fields in the state every year and may cause severe losses during certain seasons. Anthracnose is more severe under conditions of low and unbalanced soil fertility. The lower portion of the stems and sometimes the heads are affected. Tiny black spore masses may dot the surface of the affected tissues

and the entire portion of the head above the point of infection may be killed before the grain is half developed.

Control: Since the disease is carried over from year to year on shriveled grain and infected straw, seed should be thoroughly cleaned, treated, and the crop rotated. See page 22 for a full discussion of seed treatment.

Ergot

Ergot (Fig. 5) is only occasionally found on rye in Virginia. The importance of ergot is due not so much to its causing a reduction in the yield of the rye crop, but rather to the danger to animals from eating the ergot bodies developed by the fungus. Such serious diseases of horses, cattle, and even human beings, as ergotism, gangrene, and abortion, are caused by eating large quantities of grain, straw, or flour containing ergot. Small amounts of the poison are accumulated slow-

Figure 5.—Ergot of rye. (Note the sclerotia)

ly, and the disease may become chronic. There is no effective antidote for ergot poisoning.

Control: If rye or other gains are found to be infected with ergot, they should be thoroughly cleaned in a fanning mill to remove as many ergot bodies as possible before the grain is used for feed. The screenings should not be fed to animals. Only seed free from ergot should be planted.

Stem Smut

Stem smut, although not a very destructive disease on rye, is occasionally found. This smut differs considerably from the other cereal smuts in that all above-ground parts of the rye plant are affected. The first symptom of the disease may appear when the stalks are from 6 to 12 inches tall, when the affected leaves and stems become distorted and darker green in color. Before the plants head, long, narrow parallel, lead-gray smut stripes appear beneath the leaf surface. Later, the leaf surface ruptures, exposing the dark smut spore mass. Later the affected stems and leaves split and twist. Stunted and distorted plants seldom produce heads.

Control: The spores causing stem smut are carried over from year to year on contaminated seed. Chemical seed treatment as recommended on page 22 will control stem smut.

Miscellaneous Diseases of Rye

Other diseases such as *mosaic, head kernel smut, bacterial leaf blight,* and *Septoria leaf spot* sometimes occur on rye but are not considered to be of economic importance.

Miscellaneous (common to all small grains)

Sooty Mold

Sooty mold is caused by several dark colored saprophytic fungi. It often causes considerable concern during harvest time. A black sooty mold frequently covers the chaff and entire head. The mold often becomes very conspicuous if wet, muggy weather occurs while the grain is maturing (Plate 1). Sooty mold usually is not the cause of losses but only the signal that other diseases, etc., may be active. Grain from crops affected by sooty mold is sometimes small and shriveled, and this mold is blamed for the reduction in yield. Research workers, however, have shown that this shriveled grain and consequent reduction in yield is not caused by sooty mold fungi, but by diseases such as rust, mildew, scab, or insects, or by unfavorable growing conditions.

Sooty mold does not appear until the grain is mature and then it lives primarily on the dead chaff. No control measures are suggested since the disease is not considered to be very harmful.

Root Rot Disease-Complex

A root rot disease-complex has been responsible for severe losses to small grains in recent years. The most severe injury occurs during late fall and early spring. Some have attributed this loss to winter injury, drought injury, or to insects. Investigations by the experiment station have shown that the meadow nematode is often responsible for such injury. Meadow nematode root rot has been found on all small grains, corn, legumes, tobacco, and many of the grasses.

In the late fall and early spring, small grains affected with the root rot disease-complex appear unthrifty and pale. Bare patches may be evident in the field. Individual plants are often stunted or severely injured. The older leaves on affected plants are pale green to lemon yellow in color. Often many dead leaves are to be found at the crown of such plants. Severely affected plants are generally 'heaved" from the soil during periods of freezing and thawing. However, it is not unusual for diseased plants to show injury before freezing weather occurs in the fall.

Control: Very little is known concerning the control of the root rot disease-complex. It seems to be more severe in lighter soils. Treating the seed with a recommended fungicide, outlined on page 22, and planting the crop in rotation, will reduce this disease. In some instances high nitrogen fertilization has helped to reduce injury from root rot complex.

Frost and Winter Injury

Frost and winter injury occurs to some extent most years. The damage is usually localized, although occasionally it may be over extensive areas. The damage usually occurs first in the fall on the tender new growth (especially on barley). In Virginia late spring frosts are most destructive. Small grains growing in low water-logged areas are frequently badly damaged. Over fertilization may cause succulent, tender growth which is easily damaged by cold.

Leaf, crown, and young crown roots are frequently injured. The entire leaf blade, or bands of tissue may be frosted, resulting in browning and killing of the leaves. The frosted crown, buds, and young roots are first water soaked and later show necrosis and browning. Frequently these frosted areas furnish avenues for the entrance of parasitic fungi, especially the crownrot type. Frost injury during autumn affects not only the yield of grain but also the quality of the crop. Frosted kernels are frequently low in germination and seedling vigor and may lower the milling qualities of the grain.

Winter killing consists of three kinds of injury, depending on the weather conditions: (1) The freezing and drying of the seedling tissues during periods of low temperature and low humidity, (2) the depletion of food reserves in the semi-dormant plants brought about by short periods of warm weather, and (3) heaving of plants due to the freezing and thawing of the soil. The injured tissue is subject to invasion by fungi during wet, cloudy, warm weather.

Winter killing is due to a complex of factors that vary in different

regions. The prevention of winter killing depends on providing the proper soil conditions and the use of adapted varieties planted on recommended dates. Cold resistant (hardy) varieties offer one of the best means of reducing injury due to winter killing.

Seed Treatments

Prevention of losses from cereal smuts and other seed borne diseases is a problem which confronts every farmer who grows small grains. The proper treatment of seed before planting is the principal means of reducing losses caused by seed borne plant diseases. All seed that is to be treated should be first carefully cleaned by fanning to remove smut masses, weed seed, lightweight grain, and chaff. Unless the seed is already clean, or is cleaned before treatment, the results from seed treatment may not be satisfactory. There are many excellent custom seed treating operators offering seed cleaning and treating services.

The two most common seed treatments used at present are (1) chemical disinfectants (dust, slurry and solution) and (2) hot water. A new loose smut control treatment, the long water-soak, has recently been reported to be quite effective but may cause severe injury to some varieties. This new method, however, is less difficult and exacting to apply than the old one.

Chemical Treatment

Seed treatment with an appropriate fungicide helps to assure the grain grower of establishing good plant stands. It should be a regular practice. Although most seedsmen sell treated seed, the grower should treat any untreated lots, either purchased or home grown. Seed treatment destroys several seed borne fungi that cause plant diseases, checks soil-infesting fungi that rot the seed or kill the seedlings, and helps control weeds by establishing better stands of grain.

The treatment of seed with a recommended fungicide will largely prevent stinking smut of wheat, loose and covered smuts of oats, and seed borne stripe disease and the covered and black loose smut diseases of barley. It will also help to reduce the amount of scab on wheat and barley. It will not control loose smut of wheat and brown loose smut of barley. Fungicides protect the seed until conditions are favorable for germination and if properly applied do not reduce the germination of the seed.

First clean the seed to remove weed seeds, light grain, and debris. The moisture content of the seed should be low at the time of treatment (14 percent or less). Make the treatment at least 24 hours before sowing the seed so that the chemical fumes can penetrate throughout the lot of seed. The treatment may be made 1 or 2 months in advance of planting (if dry, sound, undamaged seed is treated) and stored in a dry place immediately.

Seed treatment can be done quickly, but requires a mixing machine (Fig. 6). Commercial treaters, home-made treaters, concrete mixers, or churns can be used. Ask your county agent for plans for building a home-made seed treater.

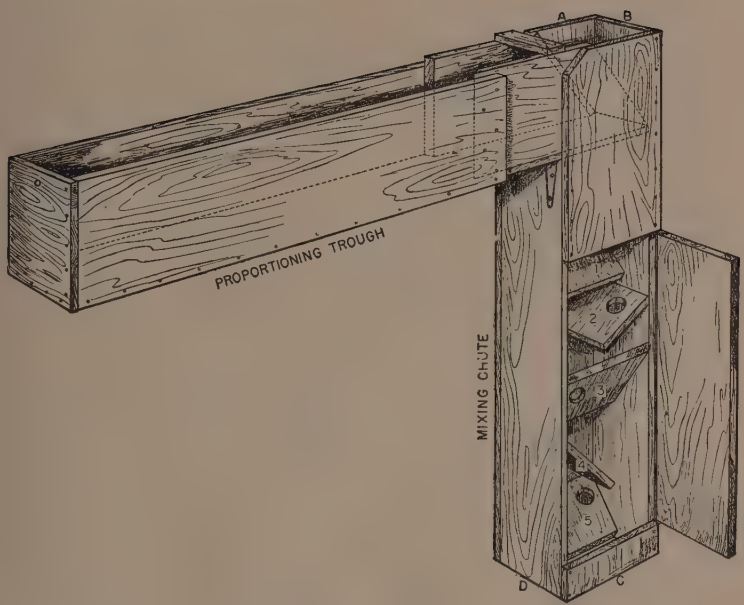

Figure 6.—General view of a home-made seed-grain treater.

The Chemicals Recommended

For wheat, oats, barley and rye use Ceresan M or M2X, Panogen, or Mema according to manufacturers' directions. There are several new materials that look promising, but more research work is needed before definite recommendations can be made.

Procedure: Add the preferred fungicide at the recommended rate to the seed; run the seed through treater and place in bags.

Precautions for chemical treatment: Chemical seed treatments call for special precautions. Like flour, cement, and many other substances, the mercury dusts are injurious to the lungs if inhaled in large quantities. Unlike these apparently harmless substances, however, most seed disinfectants are poisonous; therefore, care is required not only to avoid breathing the fumes but also to avoid their prolonged contact with the skin.

Treating machines using dust should always be so located in the building that any flying dust will be carried quickly out-of-doors. Wear a clean, dry cloth or a filter mask over the nose and mouth. Change the cloth or filter pad often enough to maintain a clean filtering surface. This dust hazard is removed when the "slurry" and "wet" treatments are used. Avoid accumulation of chemical on skin.

Seed treated with most chemicals is poisonous and should be kept out of reach of animals. Any treated seed not needed for planting should be burned or buried; or if it is to be saved for planting the following year, it should be plainly labeled and carefully stored.

Dry seed (containing 13 percent moisture or less) may be treated 2 or 3 months prior to planting if stored in a cool, dry place. It is always advisable to hold treated seeds in sacks or in bulk for at least 24 hours before planting, to permit the volatile gasses to penetrate into the seed coat. Treated seed should not be stored in air-tight containers.

The Hot-water Treatment for Loose Smuts of Wheat and Barley

Since the disease organisms causing loose smut of wheat and brown loose smut of barley are carried within the seed, surface seed treatments with chemicals are not effective. The most effective way to control these two diseases is to soak the seed in hot water.

While very effective, this method has many features which make it impracticable for the average farmer. It is slow and cumbersome, and great care is required to hold the water at the proper temperature, since a variation of only 3° Fahrenheit may either fail to control the disease or injure the germination of the seed. It is for this reason that the hot-water treatment is recommended only to obtain smut-free seed for a small seed plot from which loose-smut free seed may be obtained for general seeding the following year. The hot-water treatment should be attempted only where there is an ample supply of steam and suitable vats. Drying facilities, such as a corn dryer, are desirable for rapid drying.

Procedure for treating wheat:

Clean the seed with a fanning mill and place ½ bushel in a loose burlap sack (do not use grain sacks). Tie the sack near the top to allow for expansion. Pre-soak the seed about 6 hours in cold water (a pond or stream is satisfactory). Then transfer to a hot-water bath at 120° Fahrenheit, leaving it in the bath to warm for about 2 minutes. Remove the warmed seed and place it in a second-hot-water bath held at 129° Fahrenheit for exactly 10 minutes. After the seed has soaked 10 minutes, remove, dip in cold water, and spread to dry.

Presoaking the seed softens it and thus allows more uniform heat penetration. The seed is warmed first at 120° to avoid excessive cooling of the final heating bath. A reliable floating (dairy) thermometer is necessary, and the temperature must be very carefully regulated. Live steam for heating the water is essential. A creamery, canning plant, or milk plant is often a convenient place to work. The larger the volume of water used, the more evenly the temperature can be maintained. The sacks should be agitated while in the hot water, to permit uniform heating. The temperature of water used in treating wheat should be kept as nearly as possible at 129° for the 10-minute period, and not rise above 132° nor fall below 126°. It is a good idea to have the water at 132° at the start, as the temperature of the water will fall slightly after the grain is added. It is usually necessary to add hot water or steam during the treating process to maintain the proper temperature.

Care must be exercised in drying the seed properly after treating. To accomplish this, spread the seed in a thin layer on a dry surface (do not use a concrete floor) and stir it frequently. The seed may be planted soon after treating, provided the drill is set to allow for the swollen condition of the seed (1 peck more per acre); or, if thor-

oughly dried the grain may be stored for later seeding. A germination test should be run on the treated seed because the hot-water treatment often reduces the percentage of germination and thus makes it necessary to use a higher rate of seeding.

It is advisable to treat the seed chemically as recommended on page 22 after the hot-water treated seed is dry. This will protect the seed from soil borne organisms.

Procedure for treating barley: Follow the same procedure as given above for wheat, except that barley should be treated for 13 minutes at 126° Fahrenheit instead of 10 minutes at 129° Fahrenheit. Pre-soaking, warming, spreading, drying, and testing should be done exactly as for wheat.

A New "Cold-water Treatment" for Loose Smut

The following method has been used experimentally in North Carolina and has given very good results with barley. It is suggested for trial only. Tests on wheat are not yet complete.

Soak barley seed in water for 2 to 4 hours, either in bulk or in bags (not over half full). The temperature of the soaking water should be between 75 and 85° Fahrenheit. The grain is allowed to drain until water stops dripping, and then placed in air-tight containers. In the experiments they used 55-gallon steel drums with tight-fitting clamp-on lids, plastic bags, containers with a heavy weight plastic sheet tied securely over the top, and canning retorts in community canning plants as containers for the treatment. The time of treatment (in air-tight containers) was adjusted to the average temperature during treatment as follows: 30 hours at 90° F., 40 hours at 85° F., 50 hours at 80° F., or 60 hours at 75° F. The average temperature was estimated by averaging the maximum and minimum temperatures for the treatment period. Heat penetrates very slowly into, or out of, the treating containers; therefore, the grain should be near the average treatment temperature when placed in the containers. Treatment at temperatures of 70° F. or below failed to give consistently good control. The grain can be planted immediately after treatment or dried and planted later. Reduction in seed germination varies considerably with the seed lot and variety. In general, germination percentages have been higher following the anaerobic treatment than following the standard hot water treatment and smut control has been just as good.

While this treatment has less exacting temperature requirements than the hot water treatment, it is probably still too complicated for the average grower. Its usefulness will be principally for seedsmen.

Certified Seed

In the preceding pages the principal diseases of small grains have been discussed and recommendations given for their control. In almost every instance, disease control depends upon the planting of disease-free treated seed. The use of certified seed is the farmer's best assurance that the seed he is planting is of high quality.

Certified seed is of known ancestry and conforms to high standards of purity, germination, quality, freedom from disease, and

trueness of variety. The standards for certifying seed in this state are drawn up by the Virginia Crop Improvement Association and the State Certified Seed Commission. Seed satisfactorily meeting these requirements is eligible to be sold under the certification tag of the association. In determining whether a crop meets the requirements for certification, field inspections are made while the crop is growing, bin inspections after the seed is harvested and recleaned.

Further particulars regarding the production or purchase of certified seed may be obtained by writing to the Virginia Crop Improvement Association, Blacksburg, Virginia.

ARE DISEASED CEREALS POISONOUS TO LIVESTOCK?

People frequently ask whether diseased wheat, oats, barley, and corn will cause injury if fed to livestock.

Smutty grain should not be fed to livestock. We do not have proof of its being poisonous, but it is believed to be the cause of loss of appetite and there is some suspicion that it may promote abortion.

Grain affected with scab should not be fed to hogs because it causes them to vomit and "go off" feed, and grain affected with ergot should not be fed to any kind of livestock. See page 19.

Grain infested with nematodes is not injurious to livestock, although is is not relished by them.

SCIENTIFIC NAMES OF CAUSAL FUNGI

Host and common name of diseases	Causal Organism
Wheat:	
Stinking smut or bunt	*Tilletia caries and T. foetida*
Loose smut	*Ustilago tritici*
Black stem rust	*Puccinia graminis tritici*
Orange leaf rust	*Puccinia rubigo-vera tritici*
Scab, or Fusarium blight	*Fusarium and Gibberella* spp.
Nematode disease	*Anguina tritici*
Powdery mildew	*Erysiphe graminis tritici*
Glume blotch	*Septoria nodorum*
Take-all	*Ophiobolus graminis*
Root rots and seedling blight	*Helminthosporium, Fusarium, Pythium* spp.
Oats:	
Loose and covered smuts	*Ustilago avenae* and *U. kolleri*
Crown rust	*Puccinia coronata*
Stem rust	*Puccinia graminis avenae*
Victoria blight	*Helminthosporium victoriae*
Helminthosporium foot rot	*Helminthosporium sativum*
Barley:	
Covered smut	*Ustilago hordei*
Brown loose smut	*Ustilago nuda*
Black (false) loose smut	*Ustilago nigra*
Stripe	*Helminthosporium gramineum*
Scald	*Rhynchosporium secalis*
Powdery mildew	*Erysiphe graminis hordei*
Spot blotch and net blotch	*Helminthosporium sativum* and *H. teres*
Rye:	
Anthracnose	*Colletotrichum graminicolum*
Ergot	*Claviceps purpurea*
Stem smut	*Urocystis occulta*

Upper left: Barley leaves infected with bacterial blight, and healthy leaf. Upper right: Oat leaves infected with the red or summer stage of the crown rust fungus. Lower left: Barley leaves, healthy and infected with powdery mildew. Lower right: Oats infected with Victoria blight.

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